ENTOMOLOGY.[1]

On the Methods of Experiments in Economic Entomology.[2]—The establishment by the United States Government of an agricultural experiment station in connection with each of the state Agricultural Colleges has resulted in a great increase of attention to experiments in economic entomology. This increased attention has brought clearly to light the inadequacy of the methods commonly employed in experiments in this field. In fact the state of entomological science is such that he who wishes to conduct careful experiments, except in a few simple lines, is first forced to develop the methods of investigation.

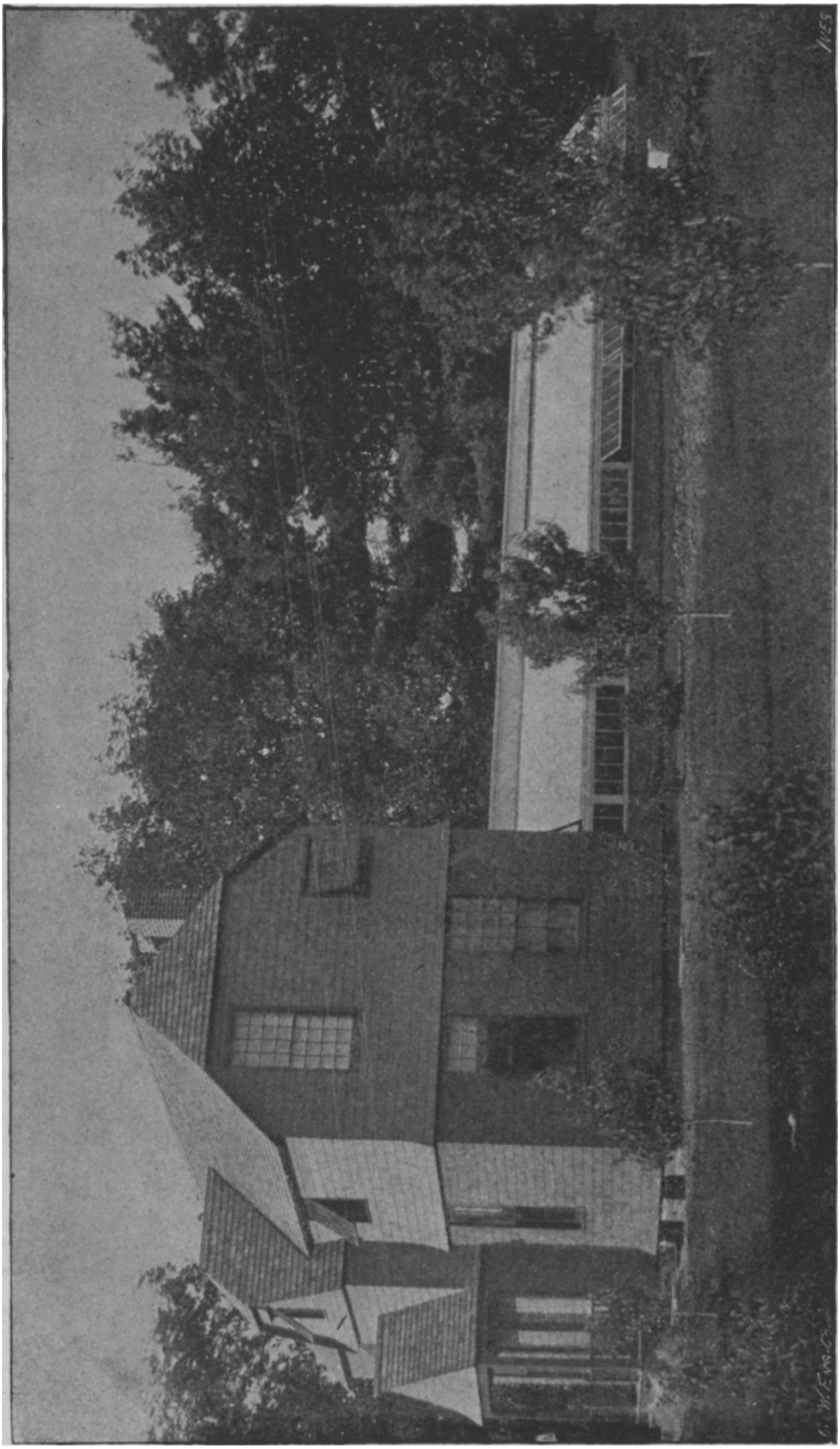
Although there are many entomologists engaged in research, and although the literature of the subject is a vast one, more than a score of journals being exclusively devoted to this specialty, comparatively little is done in the study of the transformations and habits of insects, or in making practical applications of entomology. With the exception of a few government entomologists, the energies of the workers in this field are almost entirely devoted to the description of species. And although a few workers have achieved very important results in the study of the habits of insects, and in making practical applications of the facts observed, they have done this with very crude apparatus, and often by methods which cannot be relied upon to give exact results. While magnificently equipped laboratories of physiology and histology are springing up at all of the scientific centres, the student of the habits of insects contents himself with a few breeding cages scarcely better than those used by Réaumur a century and a half ago.

An illustration of the imperfection of the methods commonly employed is the fact that experiments with insecticides are usually conducted only in the field, where the conditions cannot be controlled. I have before me a report of an experiment made to test the efficiency of a certain substance as an insecticide. The insects experimented upon were root-feeding larvæ. A careful examination of the field made at the close of the experiment revealed five times as many larvæ upon the roots of the plants treated with the supposed insecticide as there were upon an equal number of plants that had not been treated. It is evident that the application had no effect as an insecticide. But would this conclusion have been so evident had the Experimenter happened to have treated the

[1] This department is edited by Professor J. H. Comstock, Cornell University, Ithaca, N. Y., to whom communications, books for notice, etc., should be sent.

[2] Partly from the advance sheets of the Report of the Cornell University Experiment Station for 1888.

PLATE XXIX.



THE CORNELL INSECTARY.

second lot of plants instead of the first? Would it not have appeared that four-fifths of the insects had been destroyed?

While it is evident that ultimately we must depend upon field experiments for demonstrating the value of methods of preventing the ravages of insects, the danger of error in such experiments is so great that it is unwise to depend upon them in working out principles upon which such methods are based. Obviously the worker in applied entomology needs a laboratory and apparatus as much as does the chemist or physiologist; and this laboratory should be different from our ordinary entomological laboratories.

The greater number of subjects which a worker in this field should investigate fall under two heads: first, studies in the life-histories of insects: second, experiments in the destruction of noxious insects or of preventing their ravages. Work in neither of these lines can be well done in an ordinary entomological laboratory. In order to make accurate investigations of this kind it is necessary that there should be a place where living plants can be kept with insects upon them, and that all of the conditions of growth of both plants and insects should be under control.

We have already given an account (*Ante*, p. 468) of the Laboratory of Experimental Entomology at Cornell University. A view of the exterior of this building is now furnished our readers. Plate XXIX.

Soon after the erection of this laboratory we found that it was desirable to designate it by a name which should distinguish it from the entomological laboratory of the University where instruction is given. As this, so far as we know, is the first building of its kind, we were forced to coin a word; and have proposed the name *Insectary* for buildings arranged for keeping or raising living insects.

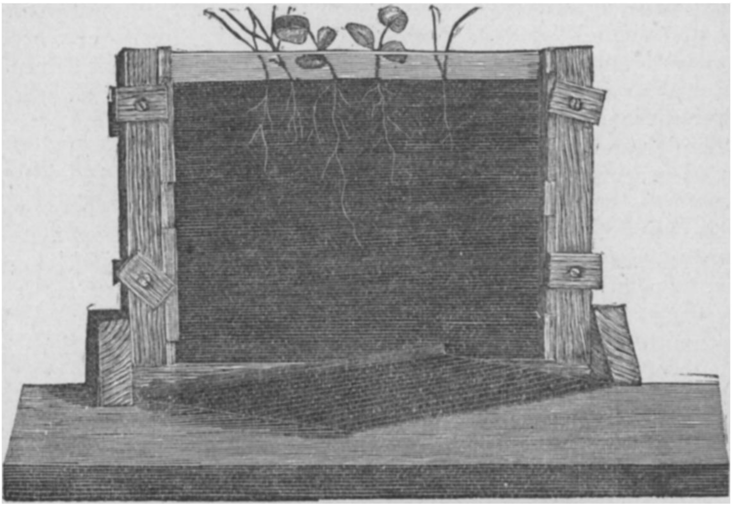
We hope that the time is near when the need of an Insectary for entomological work will be as fully appreciated as is the necessity for a propagating house for the horticulturist or a conservatory for the botanist.

But the building is not all the equipment required for the entomological work of the future. We need specially constructed apparatus for this work. The breeding-cages and the methods of observation and preservation of specimens which we have inherited from the last century will not meet all the requirements of the complicated problems we have to solve. There must be more accurate methods of observing the habits and transformation of insects, more perfect ways of testing insecticides, and better means of preserving specimens for study. It is not too much to hope that the methods of entomology of the year 1900 will be as much in advance of those of to-day, as the present methods of histology are in advance of those of fifteen years ago.

With the hope of stimulating the study of methods, I present

below descriptions of a few simple devices which I have found of much use in my entomological work.

The most important of these is a device for observing subterranean insects. This device I have termed a root-cage. It consists of a frame holding two plates of glass in a vertical position, and



only a short distance apart. The space between the plates of glass is filled with soil in which seeds are planted or small plants set. The width of the space between the plates of glass depends on the width of two strips of wood placed between them, one at each end, and can be varied according to the necessity of each experiment. Outside of each glass there is also at each end a strip of wood for holding the glass in place. The strips are fastened by means of wedges forced between them and buttons projecting beyond the edges of the end pieces, as shown in the figure. It is necessary to have wedges upon only one face of the cage. By making the three strips of wood at each end of the cage (one between the glasses and one outside of each), of different widths and interchangeable, the width of the space between the glasses can be easily varied. Immediately outside of each glass there is a piece of blackened zinc which slips into grooves in the strips at the ends, and which can be easily removed. When these zincs are in place they keep the soil dark. In the first lot of root-cages that I had made holes were bored in the bottom to provide for drainage. But the danger of the escape of insects through these holes has led me to depend on the leakage of the water through the cracks between the glass and the wood. A layer of very coarse sand one inch in depth at the bottom of the space between the glass facilitates drainage.

If the space between the two plates of glass be very narrow, when the seeds which have been sown in this cage germinate, a large part of the roots will ramify in the soil so near the surface of the glass that they may be easily seen by simply removing the piece of zinc already described. When the plants have become well established they may be infected with the insect pest to be studied, and continuous observations can be made without disturbing them. Thus at the present time I have corn growing in these cages with wire-worms feeding upon its roots. In other cages I have clover growing, the roots of which form an almost continuous mat on the inner surface of the cage. Better results can be obtained in this way than by going into the fields and digging up plants; for in most cases the moment plants are dug up the insects stop their work, while in these root-cages continuous observation of the same insect is possible.

I have had constructed several large root-cages, the frames of which are of iron, and each side of which consists of eight lights of glass, each ten inches by twelve inches in size. A pit has been dug for the reception of each cage; these pits are walled with brick. When the cage is placed in the pit, the top of it is even with the surface of the ground; by excluding the light from this pit it is hoped that the roots can be kept under nearly normal condition. These cages have been constructed for larger plants; thus we purpose to plant apple-trees in some, for the study of the root form of the Woolly Aphis of the apple; grape-vines in others in order to observe the Grape Phylloxera; and hop-vines in still others for use in proposed experiments upon the Hop Plant-louse. These cages are lifted from the ground when it is desired to study them by means of a small portable derrick.

Another form of breeding-cage which I have found very useful is made by combining an open-top bell-jar and a flower-pot. The food plant of the insect is either growing in the pot or is stuck into wet sand in the pot and kept fresh as a gardener would keep a cutting. A large saucer is used, and an inch or more of sand is placed in it. The bell-jar is placed over the plant in the pot and pressed down into the sand in the saucer. The open top of the bell-jar is covered with swiss muslin. The plant or cutting can be kept well watered by pouring water into the saucer without removing the bell-jar. The layer of sand in the saucer saves from drowning those insects that crawl down from the plants. The circulation of air through the muslin at the top prevents the formation of mould.

I have long used jelly-tumblers and fruit-jars for breeding small insects and for storing pupæ. I have been much annoyed by inability to preserve the proper degree of moisture in these receptacles If they are supplied with moistened sand and closed tightly the

specimens soon mould; if covered by muslin the sand in a short time becomes too dry and the specimens, if they emerge at all, are apt to do so in a crippled condition. I have obviated these difficulties by boring a hole in the bottom of the jelly-glass or fruit-jar and setting it in a flower-pot saucer. By pouring a little water into the saucer from time to time, the sand in the jar can be kept moistened and the excessive wetting caused by pouring water upon the sand avoided. The holes in the glass are bored by means of the end of a broken rat-tail file wet with turpentine.

Other forms of new apparatus are in use, but they are not sufficiently perfected to warrant description at this time.—*John Henry Comstock.*

EMBRYOLOGY.[1]

DEVELOPMENT OF THE PERIPHERAL NERVOUS SYSTEM OF VERTEBRATES.—Dr. Beard[2] continues his important studies on this subject, which is just now interesting some of the most distinguished of living students of the general ontogeny of the vertebrates. His results as to the origin of the ganglia of the posterior sensory roots of the spinal nerves, and of the sympathetic system, are startling and unexpected. His discoveries may also be ranked as fundamental, and amongst the greatest of recent times, as regards their consequences. The following résumé of his conclusions is given in his own words:—

"The spinal ganglia of vertebrates are formed as differentiations of the inner layers of the epiblast just outside the limits of the neural plate. As the result of the cutting out from the epiblast of these ganglionic elements an appearance is presented by the epiblast which is left, to which Professor His gave the name of 'Zwischenstrang.' This has no share in the formation of the ganglia. The 'Zwischenrisme' of His has no existence, but certain portions of the cranial ganglia, called here neural ganglia, are developed from the epiblast before closure of the neural tube, *in exactly the same way as the spinal ganglia.* These portions of cranial ganglia are more or less homologous with spinal ganglia, possibly only with the sympathetic portion of the spinal ganglia 'Anlagen.' After separation from the epiblast, the neural cranial ganglia and the

[1] Edited by Prof. Jno. A. Ryder, Univ. of Penna., Philadelphia.

[2] Morphological Studies, II. The development of the peripheral nervous system of vertebrates, Part I., Elasmobranchs and Aves, Quar. Journ. Mic. Science, xxix., pt. ii., 1888, pp. 153–227, pls. xvi.–xxi. By J. Beard, Ph.D., B.Sc.